Spectroscopic and microscopic studies of nanoscale Sn islands formed by thermal evaporation on CaF_2 substrates

Nick Spook[1,2], Harmen J. Sielcken[1,3,4] & Paul C. M. Planken[1,2]

[1]Advanced Research Center for Nanolithography (ARCNL), Amsterdam
[2]Institute of Physics, University of Amsterdam
[3]Department of Physics and Astronomy, Utrecht University
[4]FOM institute AMOLF, Amsterdam (from September 2016)

Motivation

The Advanced Research Center for Nanolithography (ARCNL) is co-funded by ASML and has the mission of conducting fundamental physical research on topics deemed relevant to the development of ASML's EUV lithography machines. We present here our study of the formation and optical response of thin layers of tin deposited on calcium fluoride. This research was done in an effort to better understand metallic tin and the structures it naturally forms.

Sample preparation and experiment

Using a thermal evaporator, we deposited thin layers of Sn onto calcium fluoride substrates. The effective thicknesses of the Sn layers varied from 10 to 450 nm.

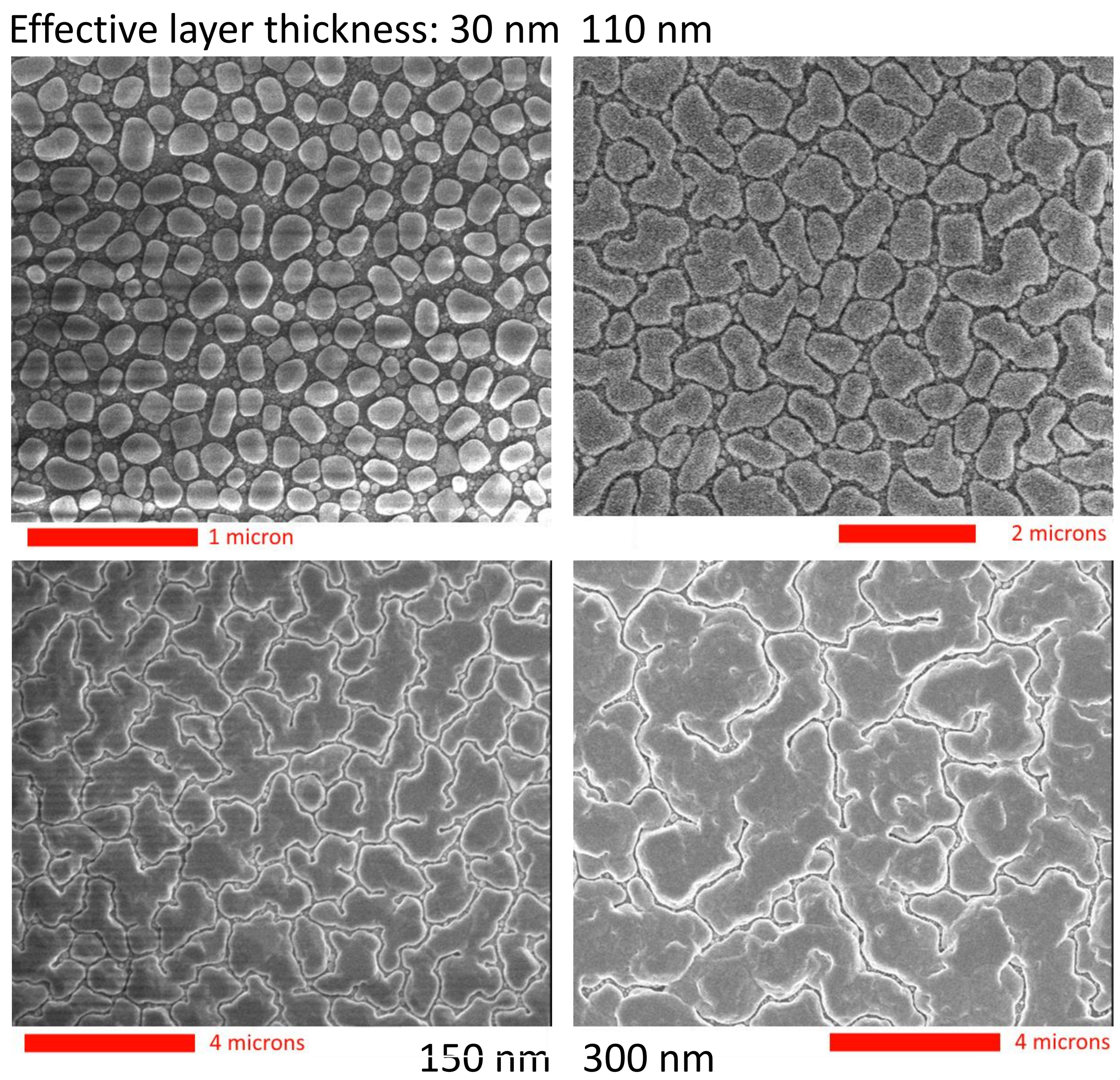
With a scanning electron microscope, we imaged the surfaces of our samples, to see the dependence of the microstructure on the effective layer thickness. The effective layer thickness was measured using a quartz crystal monitor during the evaporation process.

Using a broadband halogen lamp and two fiber-coupled spectrometers, we measured the reflection spectra of the samples in the visible and near-infrared. We extended the spectra to the mid-infrared using a Fourier transform infrared spectrometer equipped with liquid nitrogen-cooled mercury cadmium telluride detectors.

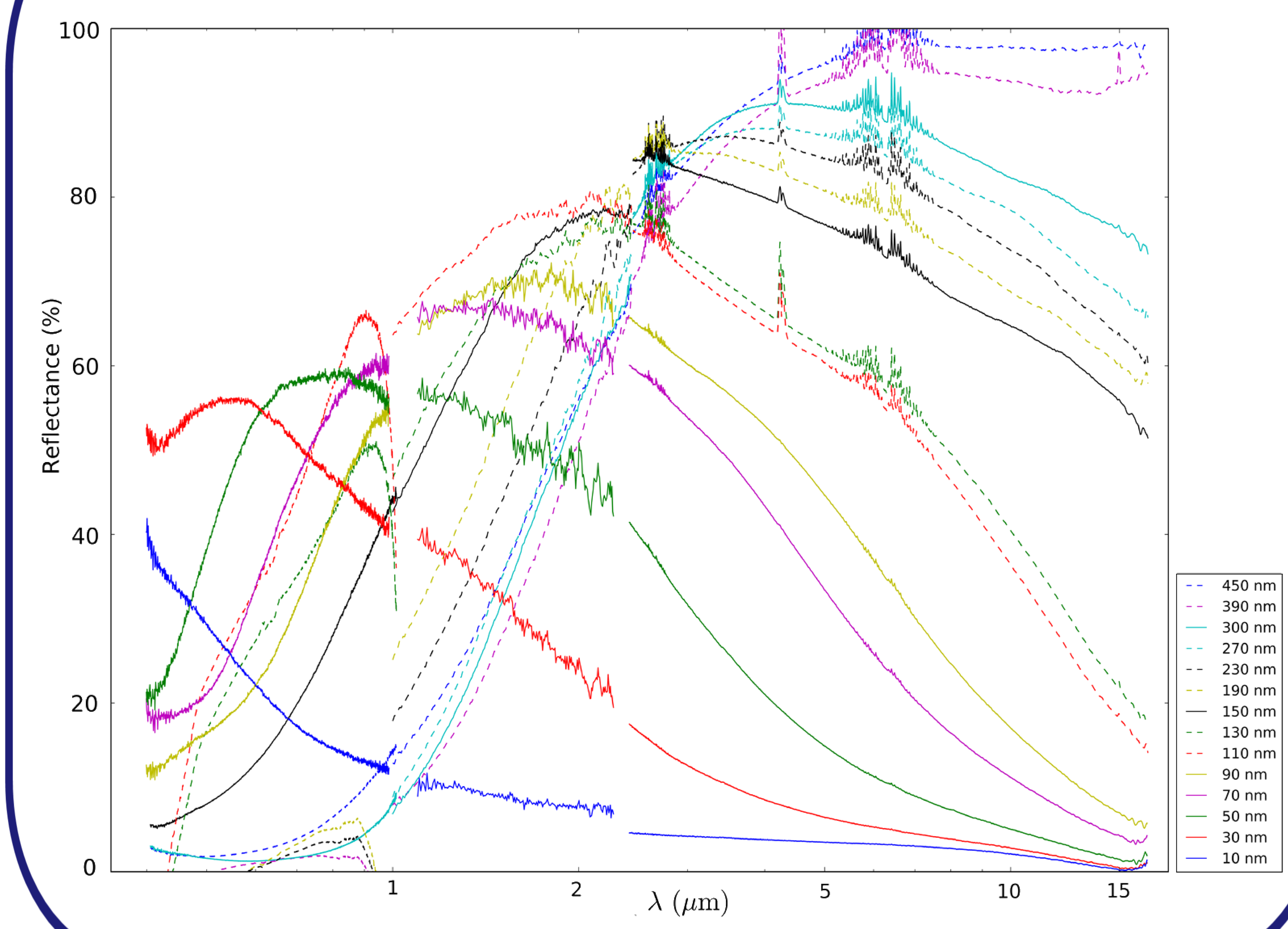
X-ray diffraction measurements* indicate that no crystalline tin oxides are present in our samples, so it seems reasonable to suppose that we have layers of metallic Sn. However, we cannot rule out the presence of *amorphous* oxide layers.

*X-ray diffraction measurements were performed by Ruud W. A. Hendrikx of the Department of Materials Science and Engineering of the Delft University of Technology.

SEM images



Spectra



Observations

We see that thin layers of Sn form small island-like structures on the surface. As the effective layer thickness increases, the islands become larger and less round. At some point, there is a transition from island-like to completely interconnected structures.
The reflection spectra seem to show a maximum that broadens and becomes redshifted as the effective layer thickness increases. For very thick layers, the reflectivity spectrum for long wavelengths tends to be very flat and high, which is expected behavior for a flat metal film.

Outlook

We are already studying the picosecond dynamics of our samples with a pump-probe experiment using mid-infrared femtosecond laser pulses. We aim to investigate how the tin responds to different intensities and laser wavelengths and how the microstructure of the samples plays a role. Also, we are preparing to study the emission of ions and uncharged debris due to pulse laser action.

FOM ARCNL University of Amsterdam VU University Amsterdam Gemeente Amsterdam NWO Nederlandse Organisatie voor Wetenschappelijk Onderzoek ASML